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Laser Processing Machine

The invention concerns a laser processing machine for processing workpieces using a laser beam, with a telescope for widening the laser beam, which comprises an ellipsoidal mirror and a paraboloidal mirror, and a method for producing the reflecting surfaces of the ellipsoidal and paraboloidal mirrors for such a laser processing machine.

An ellipsoid is an elliptical rotational solid which is generated through rotation of an ellipse about an axis of rotation, especially about one of the semiaxes of the ellipse, and is characterized by two focal distances. An ellipsoidal mirror as mentioned below means a mirror whose mirror surface is designed as ellipsoidal segment. A paraboloid is a parabolic rotational solid which is generated through rotation of a parabola about an axis of rotation, especially about the symmetrical axis of the parabola, and is characterized by one focal distance. A paraboloidal mirror as mentioned below means a mirror whose mirror surface is designed as paraboloidal segment.

Laser processing machines with scanner systems, which are used e.g. for remote welding, have movable optics in front of the deflecting mirrors (scanner mirrors), via which the focal position of the laser beam can be varied. Since the laser beam is simultaneously widened to obtain a small focal diameter, for little power, movable telescopes with transmitting optics are used, and for large power, movable telescopic systems with an ellipsoidal mirror and a paraboloidal mirror are used, which are usually designed as metal optics.

The orientation of the two mirrors with respect to each other has proven to be problematic in the design of such a telescopic system. Five adjusting axes are required to adjust the two mirrors. In addition to the large adjustment expense, the design of the telescopic system is moreover aggravated in that, at present there are

no suitable measuring methods and instruments to permit precise adjustment of the mirrors relative to each other.

It is therefore the underlying purpose of the invention to reduce the expense required for adjusting the ellipsoidal and paraboloidal mirrors of a laser processing machine of the above-mentioned type.

This object is achieved in accordance with the invention in that the axes of rotation of the ellipsoidal mirror and the paraboloidal mirror extend parallel, in particular collinear to each other. In a preferred manner, the focus of the paraboloidal mirror coincides with a focus of the ellipsoidal mirror.

The parallel and, in particular, collinear orientation of the two mirrors permits production of the reflecting surfaces of the two mirrors in one single clamping (e.g. through diamond lathe) with such precision that later adjustment is not required. In particularly preferred embodiments of the invention, the ellipsoidal mirror and the paraboloidal mirror are therefore arranged such that they are not movable relative to each other, i.e. without any adjustment means. Prior to production of the reflecting surfaces of the two mirrors, the mirror blanks may e.g. be mounted to a common carrier element and remain fixed thereto on a permanent basis.

The optical axes of the laser beam, which enters and exits the telescope, preferably extend parallel to each other. This is advantageous in that the telescope can be moved parallel to the optical axis of the laser beam entering the telescope, i.e. either in the same or in the opposite direction of the incident laser beam.

In particularly preferred embodiments, the telescope comprises an additional mirror which adjusts the optical axis of the laser beam which enters the telescope parallel to the optical axis of the laser beam which exits the telescope. Due to this measure, the telescope can be moved in the direction of the entering or exiting laser beam without requiring additional optics in the path of rays of the laser light. The additional mirror is preferably disposed in the path of rays in front of the paraboloidal mirror.

In accordance with the invention, the reflecting surfaces of the ellipsoidal mirror and of the paraboloidal mirror can be produced in one single clamping using a processing machine whose axis of rotation extends collinear to the axes of rotation of the two mirrors during production of the reflecting surfaces of the two mirrors.

Further advantages of the invention can be extracted from the description and the drawing. The features mentioned above and below can be used individually or collectively in arbitrary combination. The embodiments shown and described are not to be understood as exhaustive enumeration but have exemplary character for describing the invention. In the drawings -

Fig. 1 shows a schematic illustration of a first embodiment of the inventive telescope with ellipsoidal, paraboloidal and additional mirrors;

Fig. 2 shows a second embodiment of the inventive telescope in an illustration analogously to Fig. 1;

Fig. 3 shows a third embodiment of the inventive telescope in an illustration analogously to Fig. 1;

Fig. 4 shows a fourth embodiment of the inventive telescope in an illustration analogously to Fig. 1; and

Fig. 5 shows the inventive telescope with a common carrier element for the ellipsoidal and paraboloidal mirror.

The telescope 1 shown in Fig. 1 is disposed in front of the scanner mirrors of a laser processing machine and serves for widening the laser beam 2 of the laser processing machine and also for varying the focal position of the laser beam 2.

The telescope 1 comprises a concave ellipsoidal mirror 3, a convex paraboloidal mirror 4 and a planar additional mirror 5. The ellipsoidal and paraboloidal mirrors 3, 4 have a collinear axis of rotation 6 and are not adjustable relative to each other. The ellipsoidal mirror 3 having two foci is characterized by the two focal distances f_1, f_2

and the paraboloidal mirror 4 having one focus is characterized by the focal distance f_3. In the embodiment shown, the focus of the paraboloidal mirror 4 coincides with a focus of the ellipsoidal mirror 3.

The laser beam 7 which enters the telescope 1 is deflected by the additional mirror 5 to the paraboloidal mirror 4 and from there to the ellipsoidal mirror 3 which deflects the laser beam 8 exiting the telescope 1 or its optical axis 9 parallel to the optical axis 10 of the incident laser beam 7 and in the direction of the incident laser beam 7. Subsequently, the telescope 1 can be moved – without interposing further optical elements – in the direction of the optical axis 9 or 10, i.e. in the direction of the double arrow 11, whereby the focal position of the exiting laser beam 8 can be varied.

In contrast to the telescope of Fig. 1, the paraboloidal mirror 4 of the telescope 1 shown in Fig. 2 is concave and the additional mirror 5 has a different orientation to adjust the incident laser beam 7 or its optical axis 10 parallel to the optical axis 9 of the exiting laser beam 8.

The telescope 1 of Fig. 3 differs from the telescope 1 of Fig. 1 in that the additional mirror 5 adjusts the incident laser beam 7 or its optical axis 10 parallel to the optical axis 9 and opposite to the exiting laser beam 8.

The additional mirror 5 of the telescope 1 of Fig. 4 is disposed such that the optical axis 10 of the incident laser beam 7 is directed at a right angle to the optical axis 9 of the exiting laser beam 8.

As is shown in Fig. 5, the ellipsoidal and paraboloidal mirrors 3, 4 are fixed on a carrier element 12 such that they cannot be mutually adjusted, already before production of their reflecting surfaces through diamond lathe. The axis of rotation of the processing machine in which the carrier element 12 with the mirror blanks is clamped extends collinear to the axis of rotation 6 (not shown in Fig. 5) of the two mirrors 3, 4 during production of the reflecting surfaces of the two mirrors 3, 4. The additional mirror 5 can be separately mounted or also be mounted on the carrier element 12.